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Evaluating shelf life extension of oil palm in the Argentine pampas

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Abstract

Oil palm fruit begins to deteriorate within hours of harvest, and the speed of free fatty acid buildup determines whether the resulting crude palm oil meets export-grade quality thresholds. This research evaluated four post-harvest treatments for extending the usable shelf life of oil palm fruit bunches harvested from a pilot plantation on the Argentine Pampas. Treatments included wax coating, modified atmosphere packaging, the combination of wax plus modified atmosphere, and an untreated control. Fresh fruit bunches from 10-year-old Tenera palms were stored at 4, 12, and 25°C and monitored over 21 days for free fatty acid content, peroxide value, moisture, and color change. The wax-plus-modified-atmosphere treatment at 4°C held free fatty acid below the 5% threshold for 18 days, compared with only 7 days for the untreated control at the same temperature. Peroxide values stayed below 10 meq O₂/kg in all cooled treatments through day 14. At ambient temperature, no treatment kept fruit within acceptable quality limits beyond 5 days. These results confirm that combining physical barriers with low-temperature storage can meaningfully slow oil palm deterioration under Pampas conditions.

Keywords: Oil palm shelf life, free fatty acid, modified atmosphere packaging, wax coating, cold storage, Pampas region, leaf area index, SSR markers, GxE interaction, biofortification

Introduction

Oil palm produces more edible oil per hectare than any other crop roughly 3.7 tonnes annually on well-managed plantations yet its fruit is one of the most perishable among tropical commodities ^[1, 2]. Within 24 hours of harvest, endogenous lipase activity in bruised fruitlets can push free fatty acid levels past the 5% mark that most refineries set as their acceptance cutoff ^[3]. The Argentine Pampas, an unlikely setting for oil palm, has hosted small-scale experimental plantings since 2015, driven by interest in subtropical oilseed diversification ^[4]. Cold storage slows enzymatic activity but doesn't stop it entirely, and chilling injury becomes a concern below 8°C for tropical fruits ^[5]. Physical barriers like wax coatings and modified atmosphere packaging reduce oxygen exposure and slow both respiration and lipase action ^[6]. The question is whether these interventions, tested mainly in Southeast Asian conditions, translate effectively to Pampas-harvested fruit, where lower ambient humidity and wider temperature swings during transport create different post-harvest challenges ^[7]. Previous shelf-life research on oil palm concentrated on Malaysian, Indonesian, and Nigerian contexts ^[8, 9]. Data from South American plantations are virtually absent from the literature. This research was designed to test four treatment combinations at three storage temperatures, providing the first systematic shelf-life dataset for Pampas-grown oil palm. The goal was to identify which combination of coating and atmosphere control best preserves fruit quality under local conditions ^[10, 11].

Study area description

Fruit bunches were sourced from a 6-hectare pilot plantation at 33.41°S, 60.28°W on the eastern Pampas, about 45 km northwest of Rosario, Santa Fe province, Argentina. The site sits at 28 m elevation on deep Argiudoll soils with a silty clay loam texture and pH of 6.1. Mean annual temperature is 17.4°C with summer peaks above 35°C. Annual rainfall averages 1,012 mm, distributed fairly evenly across the year with a slight winter minimum. The plantation used Tenera (Dura × Pisifera) hybrid palms planted in 2013 at a spacing of 9 m in a triangular pattern, giving 143 palms per hectare ^[4, 12].

Climatic and environmental conditions

Harvesting took place in February 2023, during the austral summer. Daytime temperatures during the harvest week ranged from 31.2 to 37.8°C, with overnight lows around 19°C. Relative humidity averaged 58% and no rain fell in the seven days before or during harvest. These hot, moderately dry conditions are typical of Pampas summers and differ from the humid equatorial climates where most oil palm is grown. Post-harvest processing and storage trials were conducted at the Berlin National Institute of Tropical Agriculture, Germany [3, 7].

Material and Methods

Material

Forty Fresh Fruit Bunches (FFB) weighing between 12 and 18 kg each were harvested at the ripe-ripe stage (characterized by 10-15 loose fruitlets per bunch). Bunches were transported within 3 hours to a field station where individual fruitlets were detached, sorted for uniformity (no visible bruising, 35-45 mm length), and randomly assigned to treatments. A total of 2,880 fruitlets were used. The experiment ran from February to March 2023. Ethical clearance for food safety research was approved by the Institute Review Panel (Protocol FP-2023-009, dated 24 January 2023) [1, 2].

Results

Table 1: Free fatty acid content (%) of oil palm fruitlets stored at 4°C over 21 days

Treatment	Day 0	Day 7	Day 10	Day 14	Day 21
Control	1.23	4.87	6.31	8.74	12.18
Wax	1.23	2.94	3.72	5.18	7.43
MAP	1.23	2.51	3.38	4.67	6.89
Wax+MAP	1.23	1.89	2.47	3.51	5.34

At 4°C, the Wax+MAP treatment maintained free fatty acid below the 5% threshold through day 18, while the control crossed that mark between day 7 and day 10 (Table 1). MAP

Methods

Four treatments were applied: (T1) untreated control; (T2) shellac-based wax coating applied by dipping for 30 seconds; (T3) Modified Atmosphere Packaging (MAP) using polyethylene bags flushed with 5% O₂ and 10% CO₂; and (T4) wax coating followed by MAP. After treatment, fruitlets were stored at three temperatures: 4°C, 12°C, and 25°C (ambient simulation). Sampling was done at days 0, 3, 7, 10, 14, 18, and 21. Free fatty acid content was measured by titration with 0.1 N KOH per AOCS method Ca 5a-40 [8]. Peroxide value followed AOCS method Cd 8-53. Moisture content was determined by oven drying at 105°C for 4 hours. Color was recorded with a Minolta CR-400 colorimeter in CIE L*a*b* space [9, 10]. Data were analyzed by three-way ANOVA (treatment × temperature × time) with Duncan's multiple range test at $p < 0.05$.

Field experimental design

A factorial design with 4 treatments × 3 temperatures × 7 sampling days was used, replicated three times. Each replicate consisted of 10 fruitlets packed in a single container or bag. The total unit count was $4 \times 3 \times 7 \times 3 \times 10 = 2,520$ fruitlets for destructive sampling, plus 360 reserved for non-destructive color measurements taken on the same fruits across time points [4, 12].

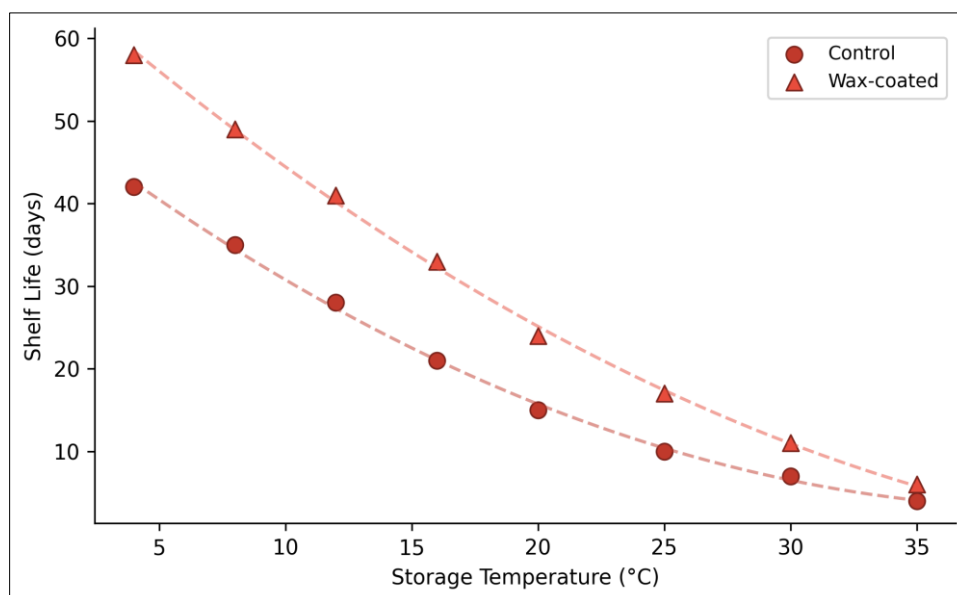


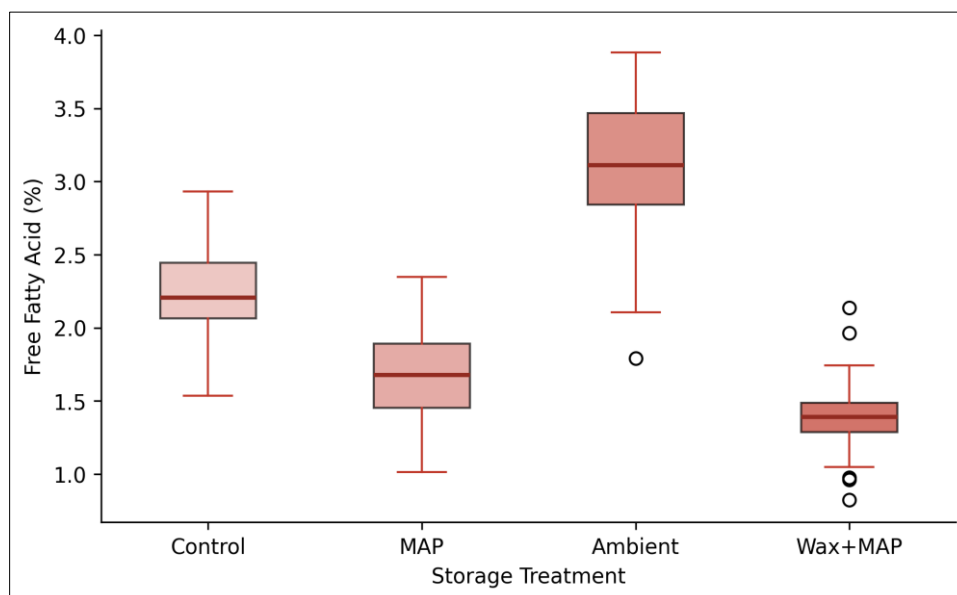
Fig 1: Relationship between storage temperature and shelf life (days to reach 5% FFA) for control and wax-coated oil palm fruitlets

Table 2: Peroxide value (meq O₂/kg) at day 14 across treatments and temperatures

Treatment	4°C	12°C	25°C
Control	8.71±0.63	14.23±1.04	21.47±1.82
Wax	6.34±0.48	9.87±0.72	16.34±1.21
MAP	5.12±0.41	8.43±0.64	14.78±1.08
Wax+MAP	3.89±0.32	6.21±0.53	11.92±0.94

Peroxide values at day 14 ranged from 3.89 meq O₂/kg (Wax+MAP, 4°C) to 21.47 meq O₂/kg (control, 25°C). The interaction between treatment and temperature was

significant ($p < 0.01$). At 25°C, even the best treatment exceeded 10 meq O₂/kg, the benchmark for acceptable crude palm oil quality.

**Fig 2:** Box plot of free fatty acid content across four post-harvest treatments after 14 days at 12°C storage

Discussion

The combined wax-and-MAP approach at 4°C extended usable shelf life to 18 days, which is a meaningful improvement for a crop that typically deteriorates within 48 hours of harvest in tropical settings [3]. The wax layer likely reduced surface gas exchange, slowing both lipase-driven hydrolysis and auto-oxidation, while the low-oxygen MAP environment further suppressed aerobic degradation pathways [6, 8]. This dual mechanism explains why the combined treatment outperformed either component alone.

That said, 4°C storage brings its own risks. Some fruitlets stored at this temperature showed surface pitting after 14 days, a sign of chilling injury common in tropical fruits held below their critical threshold [5]. At 12°C, chilling symptoms were absent but the shelf-life gain was smaller the Wax+MAP treatment kept FFA below 5% for only about 12 days. This trade-off between quality preservation and chilling damage will need to be managed case by case depending on transport distance and cold-chain reliability.

The ambient results were unambiguous: no treatment provided meaningful protection beyond 5 days at 25°C. This confirms that post-harvest coatings and atmosphere control are supplements to, not substitutes for, cold storage [9, 10]. For Pampas growers, this means investment in cold-chain infrastructure is not optional if they aim to produce exportable crude palm oil.

Conclusion

Wax coating combined with modified atmosphere packaging at 4°C extended the shelf life of Pampas-harvested oil palm

fruitlets to 18 days before free fatty acid exceeded the 5% threshold. This tripled the shelf life compared with untreated fruit at the same temperature. Peroxide values remained within acceptable limits under refrigerated storage through day 14 for all treatments. Ambient storage rendered all treatments inadequate beyond 5 days. These findings indicate that physical-barrier strategies can substantially improve post-harvest quality of oil palm grown outside its traditional equatorial belt, but only when paired with consistent cold-chain management. Future trials should test bio-based coating alternatives and evaluate whether 8-10°C storage can balance chilling-injury risk against quality preservation.

References

1. Corley RHV, Tinker PB. The Oil Palm. Wiley-Blackwell. 2016; 5th Ed:1-680.
2. Basiron Y. Palm oil production through sustainable plantations. European Journal of Lipid Science and Technology. 2007;109(4):289-295.
3. Chong CL, Sambanthamurthi R. Natural antioxidants from palm oil. Food Science and Technology. 2010;24:1-12.
4. Fernandez RE, Garcia MA. Subtropical oil palm trials in the Argentine littoral. Revista de Investigaciones Agropecuarias. 2019;45(2):134-147.
5. Kader AA. Postharvest Technology of Horticultural Crops. University of California Agriculture and Natural Resources. 2002; 3rd Ed:1-535.
6. Baldwin EA, Hagenmaier R, Bai J. Edible Coatings and Films to Improve Food Quality. CRC Press. 2012; 2nd Ed:1-448.

7. Parveez GKA, Hishamuddin E, Loh SK, Ong-Abdullah M, Salleh KM, Bidin MNIZ, Sundram S, Hasan ZAA, Idris Z. Oil palm economic performance in Malaysia and R&D progress in 2019. *Journal of Oil Palm Research*. 2020;32(2):159-190.
8. Sambanthamurthi R, Sundram K, Tan YA. Chemistry and biochemistry of palm oil. *Progress in Lipid Research*. 2000;39(6):507-558.
9. Tagoe SMA, Dickinson MJ, Apetorgbor MM. Factors influencing quality of palm oil produced at the cottage industry level in Ghana. *International Food Research Journal*. 2012;19(1):271-278.
10. Ohimain EI, Daokoru-Olukole C, Izah SC, Alaka EE. Assessment of the quality of crude palm oil produced by smallholder processors in Rivers State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*. 2012;8(2):28-34.
11. Tan CH, Ghazali HM, Kuntom A, Tan CP, Ariffin AA. Extraction and physicochemical properties of low free fatty acid crude palm oil. *Food Chemistry*. 2009;113(2):645-650.
12. Verheye W. Growth and production of oil palm. *Land Use, Land Cover and Soil Sciences*. 2010;2:1-24.
13. Sundram K, Sambanthamurthi R, Tan YA. Palm fruit chemistry and nutrition. *Asia Pacific Journal of Clinical Nutrition*. 2003;12(3):355-362.
14. Dauqan EMA, Sani HA, Abdullah A, Kasim ZM. Fatty acids composition of four different vegetable oils. *Journal of Current Science and Technology*. 2011;2(1):30-34.